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HF-OTH Radar Performance Results

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Radar performance forecasts for Navy Relocatable Over-the-Horizon Radars (ROTHR) using computer program RADARC Version 1.0 for Beeville, Texas and Northwest, Virginia are presented. Computer instructions to run RADARC on VMS are given to obtain data files for a location of interest. Instructions on personal computers to generate graphs for noise levels, forecast graphs and tables of availability predictions are provided in details.

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HF-OTH Radar Performance Forecasts

INTRODUCTION

HF-OTH radar performance forecasting is an important tool in selecting radar sites and system parameters for meeting mission requirements. NRL has developed the capability to make forecasts with its RADARC version 1.0, a computer program for radar performance prediction in the ionosphere.[1,2] This memo describes the forecasts, shows example forecasts for Navy Relocatable Over-the-Horizon Radars(ROTHR) located in both Texas and Virginia, and gives the steps necessary to generate a forecast.

DESCRIPTION OF A FORECAST

A forecast of radar performance shows the diurnal and monthly variations of predicted signal to noise ratio and required radar frequency for a target at selected ranges. The forecast is done for selected radar model, target model, and solar activity. The forecast uses monthly median values for ionospheric parameters and noise for the specified times and locations.

The forecast results are presented in both forecast graphs for each selected range and in a summary table. A forecast graph for a selected range is a plot of SNR and operating frequency versus time of day (0 to 24 hours local time) for each month. A forecast summary table shows the percentage of hours the predicted SNR at selected ranges exceeds given SNR values during different seasons for night and day.

EXAMPLE FORECASTS

A forecast was done for a ROTHR in Texas looking on a bearing of 130 degrees at a Cessna 206 during low solar activity(SSN=10). SSN is the sunspot number, a measure for solar activity. Figure 1 is a map showing the radar location and bearing. The radar cross section used for a Cessna is graphed in Figure 2. The combined radar antenna gains(transmitter and receiver) for four different frequencies are shown in Figure 3.

The forecast was done with an average power of 100 kW (actual ROTHR average power is between 100 and 200 kW) and a coherent integration time of 2.5 seconds. A system loss of 9 dB and 6 dB multipath enhancement were used. Figures 4-6 show the median values for various losses, noise level, gain, SNR, elevation angles, and frequencies of a typical day in January for three different ranges. DEV is the deviative loss. ABS is the absorption loss. OBF is the obscuration loss. T-loss is the sum of DEV, ABS and OBF. The noise is referenced to KT (-204 dBW/Hz). Showing the noise and losses as negative dB enables one to see clearly how the shape of SNR is affected by the noise and losses. By combining similar figures for twelve different months in the same year, retaining only SNR and frequencies, a forecast graph of SNR and frequencies for a particular range can be obtained. These forecast graphs are illustrated in Figures 7-12. In addition, Table 1 shows the forecast summary table for SNR predictions.

A forecast was also done for the Virginia ROTHR site looking at 175 degrees. Figures 13-18 show the forecast graphs and Table 2 shows the forecast summary table of SNR predictions for this particular site. In addition, a graphic representation is done for the two summary tables of SNR

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predictions. It is shown in Figure 19 for easy comparison. The SNR Predictions for these two different sites are surprisingly similar.

SUMMARY

The forecast shows that although the radar would have excess sensitivity for detection and tracking during many periods, there are periods, especially summer pre-dawn hours, when the radar performance will be marginal. Low levels of ionization require low operating frequencies, and unfortunately at the lower frequencies (5 to 10 MHz) the antenna gains and small-aircraft target cross-section are less and the noise levels are higher. Performance can be improved during those periods by operating the radar with longer dwell times and higher transmit power. Higher low band antenna gains would also improve performance.

By examing Figure 19, it can be predicted that HF-OTH radars would have similar performance in Beeville, Texas and Northwest, Virginia.

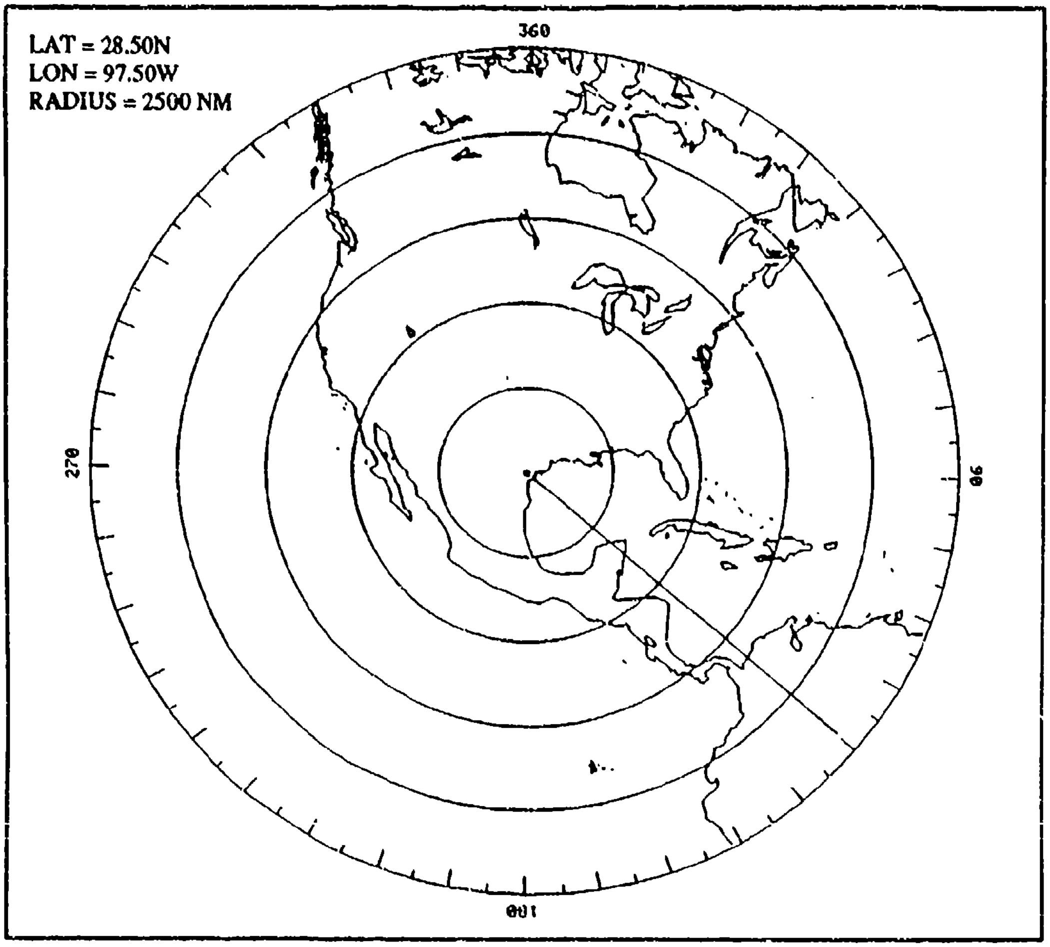

Figure 1. Map of Radar Location and Bearing in Texas.

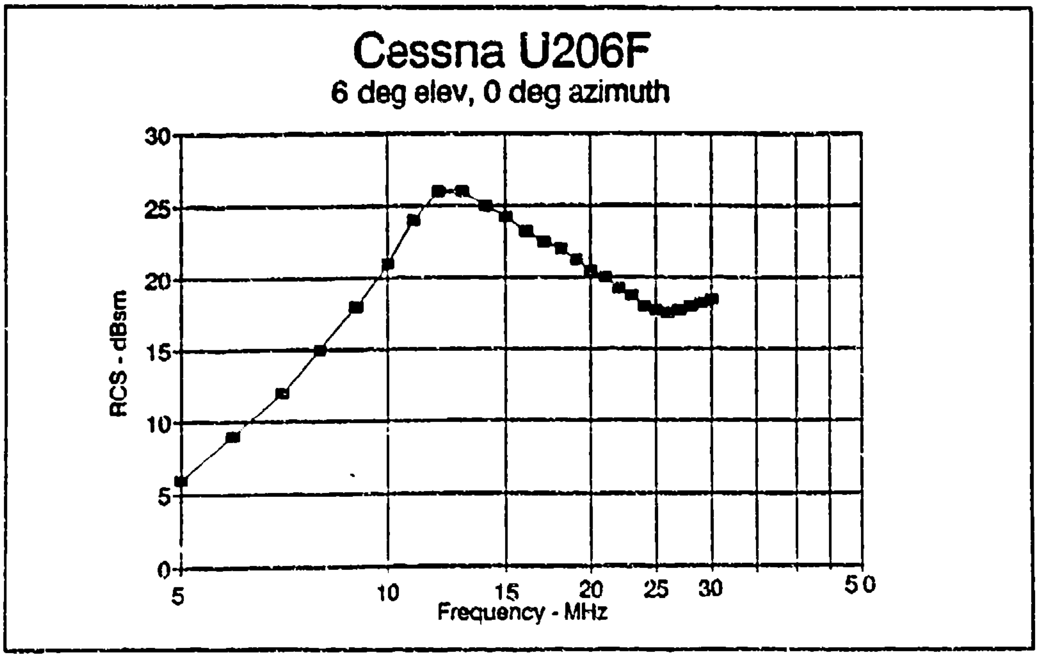

Figure 2. Radar Cross Section of a Cessna 206.
(Extracted from SRI Cross Bow Briefing)

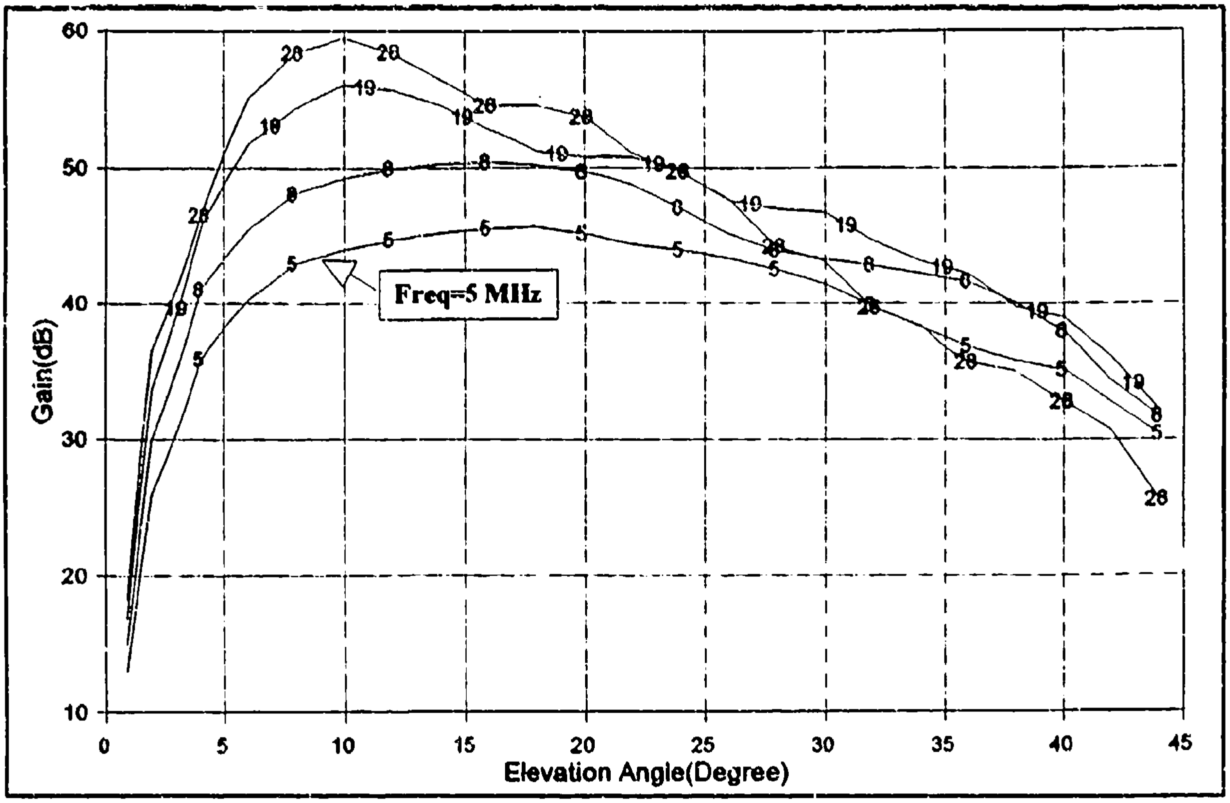

Figure 3. Combined Antenna Gains for Different Frequencies.

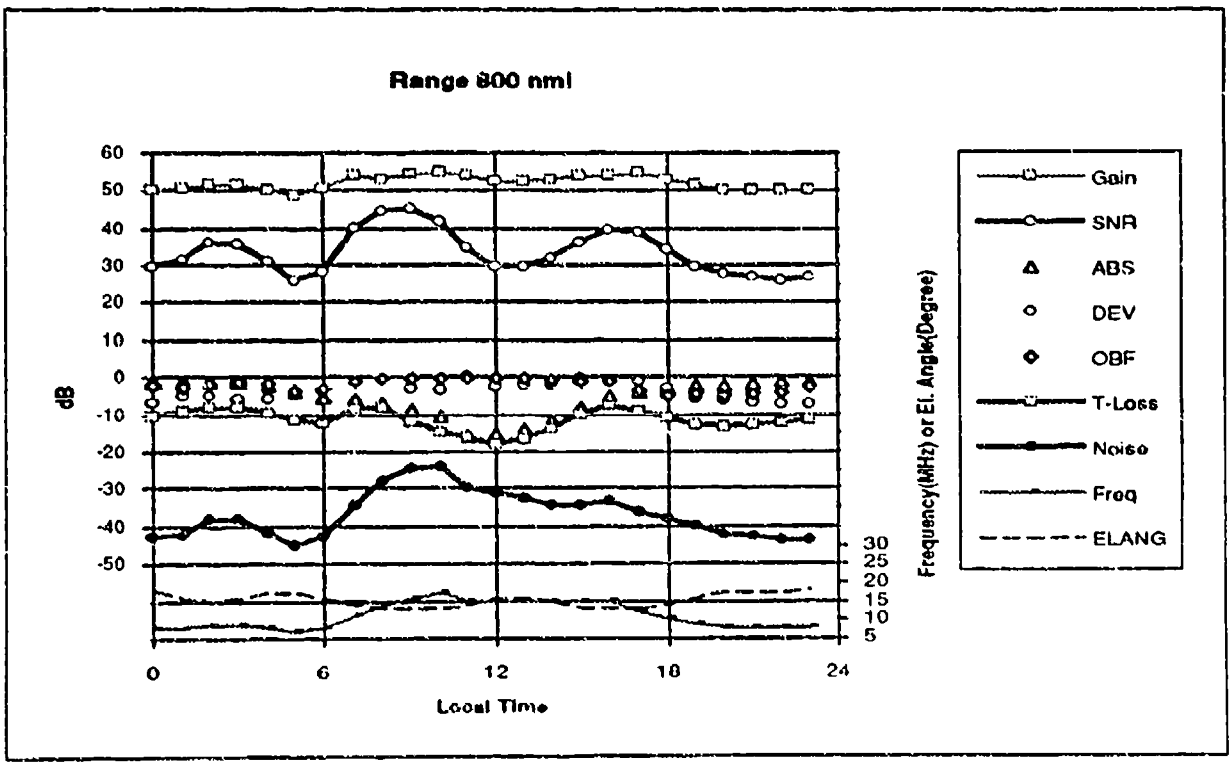

Figure 4. Noise Levels and Optimum Frequency for 800 nmi Coverage in January at Beeville, Tx. (SSN=10)

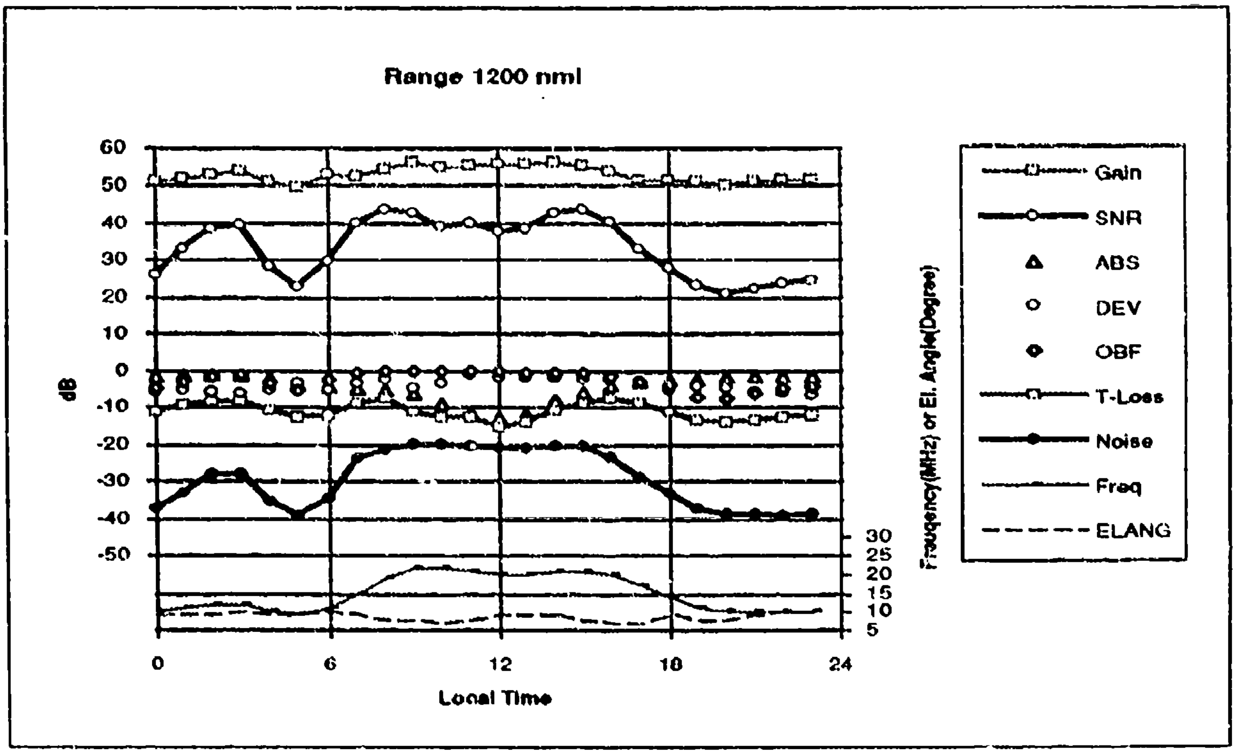

Figure 5. Noise Levels and Optimum Frequency for 1200 nmi Coverage in January at Beeville, Tx. (SSN=10)

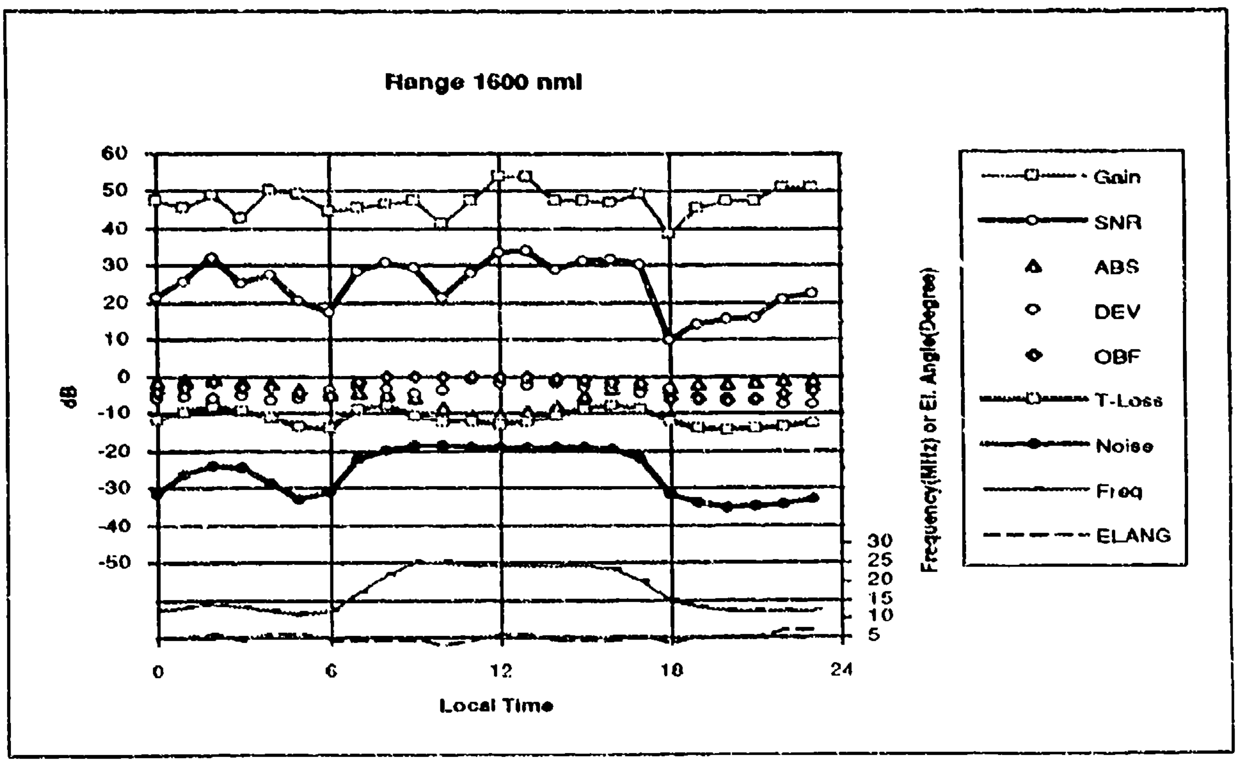

Figure 6. Noise Levels and Optimum Frequency for 1600 nmi Coverage in January at Beeville, Tx. (SSN=10)

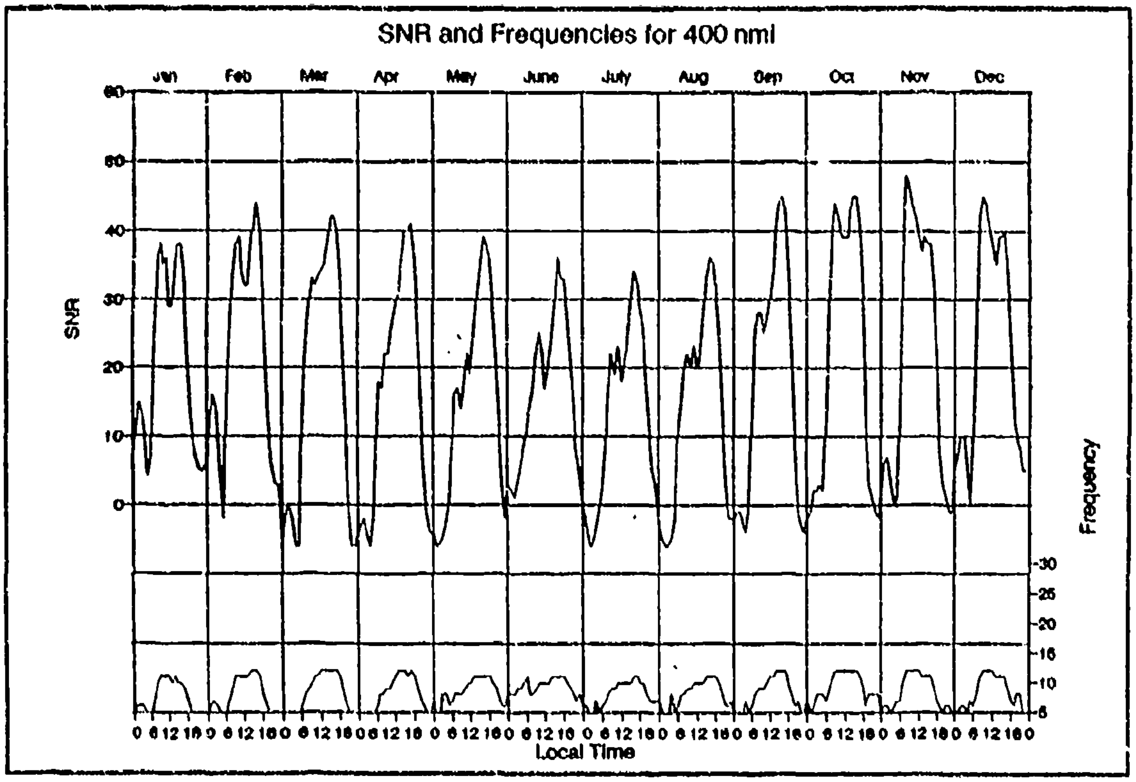

Figure 7. Forecast SNR and Optimum Frequencies for Cessna 400 nmi from the Radar at Beeville, Tx. (SSN=10)

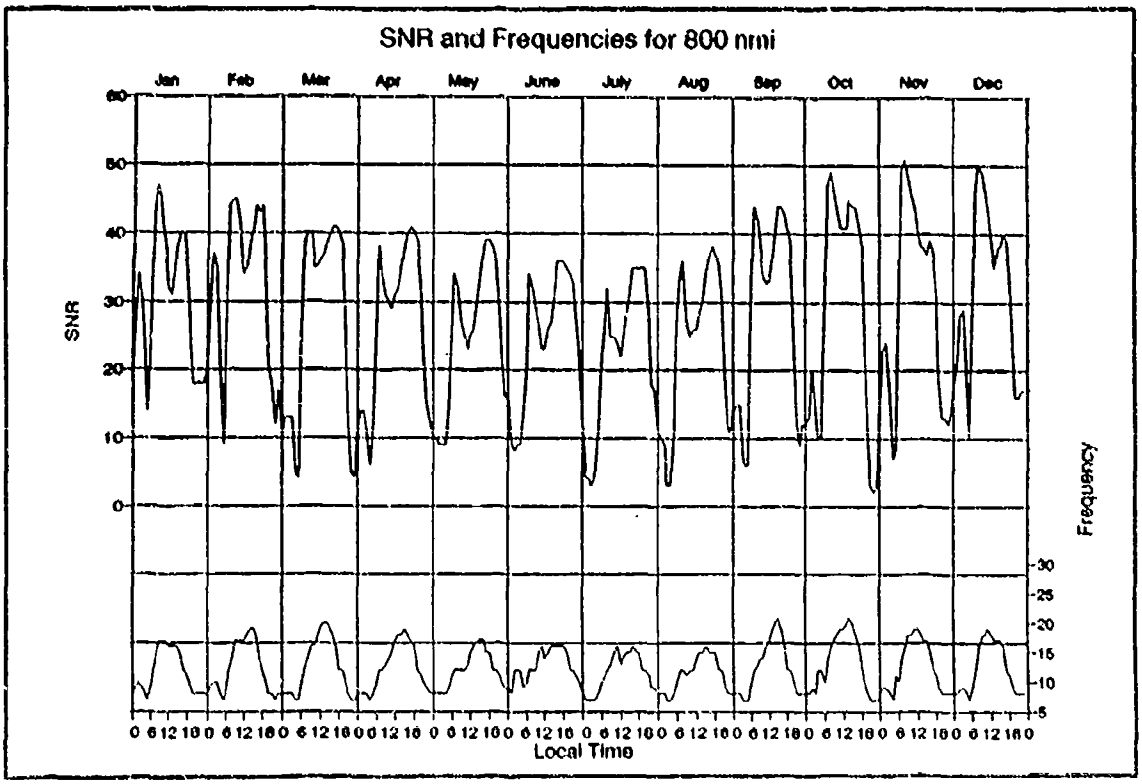

Figure 8. Forecast SNR and Optimum Frequencies for Cessna 800 nmi from the Radar at Beeville, Tx. (SSN=10)

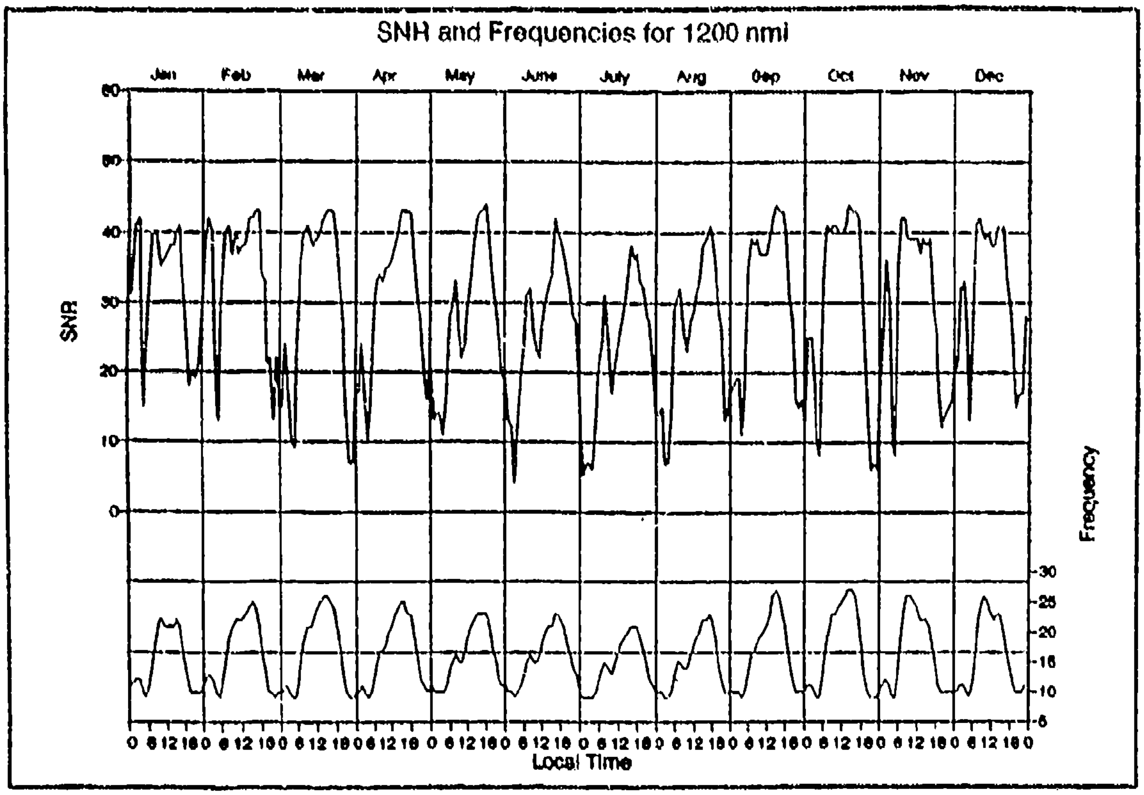

Figure 9. Forecast SNR and Optimum Frequencies for Cessna 1200 nmi from the Radar at Beeville, Tx. (SSN=10)

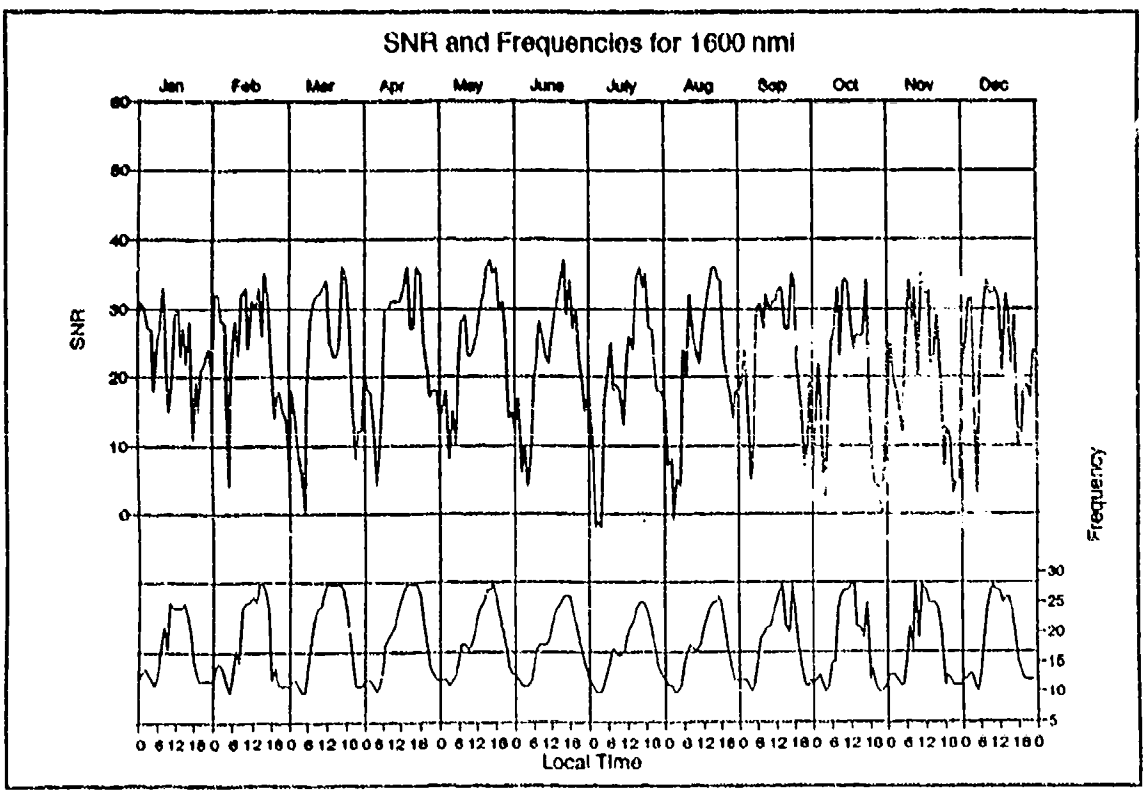

Figure 10. Forecast SNR and Optimum Frequencies for Cessna 1600 nmi from the Radar at Beeville, Tx. (SSN=10)

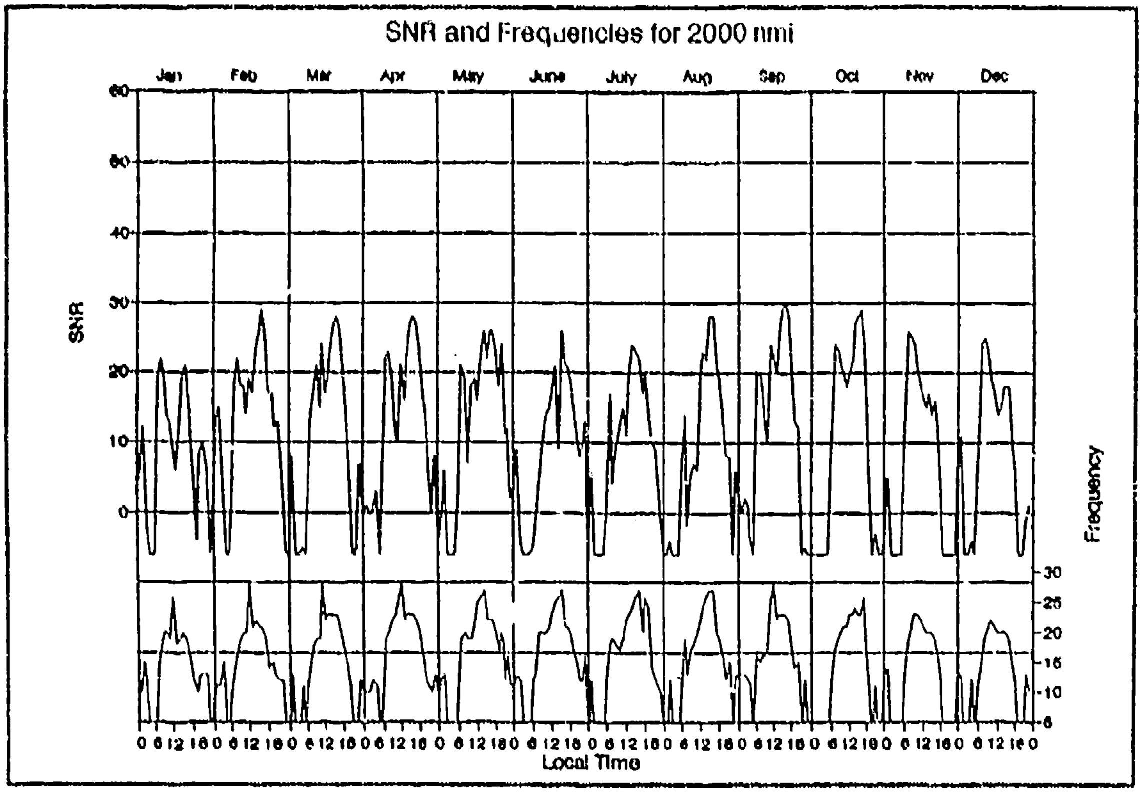

Figure 11. Forecast SNR and Optimum Frequencies for Cessna 2000 nmi from the Radar at Beeville, Tx. (SSN=10)

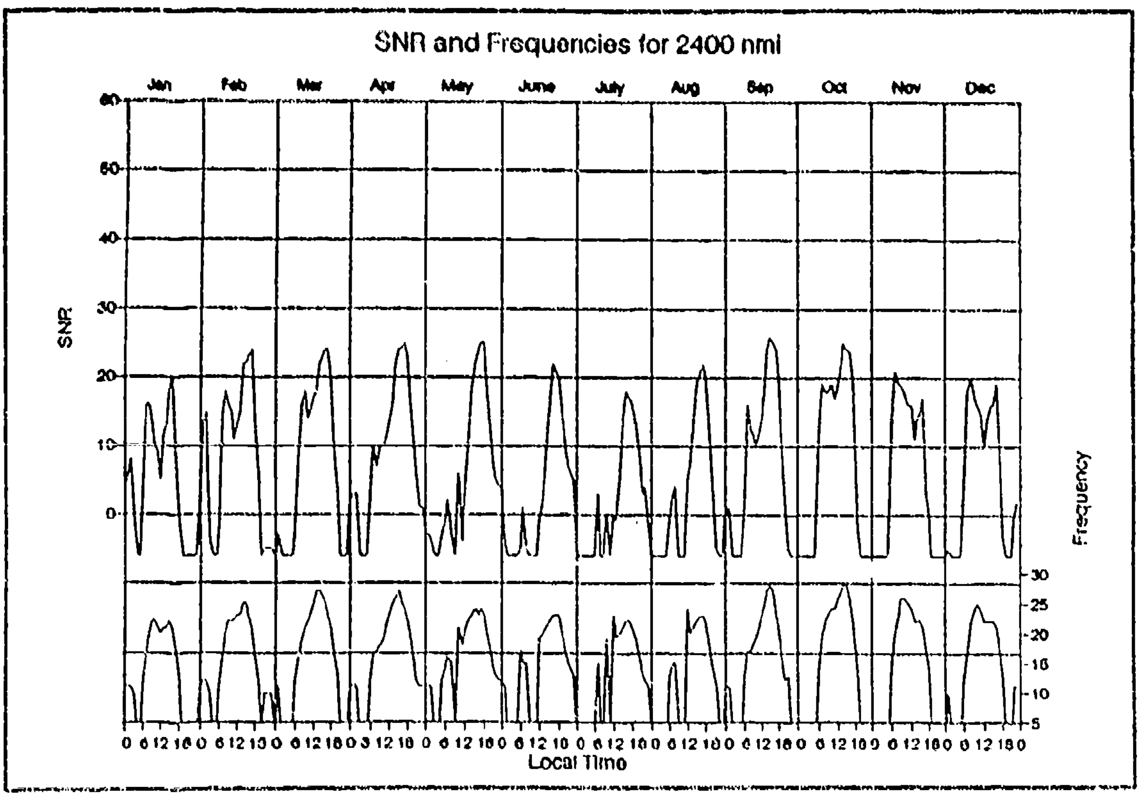

Figure 12. Forecast SNR and Optimum Frequencies for Cessna 2400 nmi from the Radar at Beeville, Tx. (SSN=10)

Table 1. RADARC Availability(%) Predictions for Cessna 206 Detection at Beeville, Tx. (SSN=10)

Target Range =	400	800	1200	1600	2000	2400 nmi
SNR > 0						
NIGHTTIME:						
WINTER:	89	95	95	95	47	26
SPRING:	31	95	95	92	50	42
SUMMER:	58	95	95	84	44	31
FALL:	52	95	95	92	26	15
DAYTIME:						
WINTER:	95	95	95	95	95	89
SPRING:	95	95	95	95	95	87
SUMMER:	95	95	95	95	89	58
FALL:	95	95	95	95	95	92
SNR > 10						
NIGHTTIME:						
WINTER:	26	89	95	89	18	5
SPRING:	21	68	81	71	18	7
SUMMER:	21	63	76	63	13	7
FALL:	13	65	76	55	13	5
DAYTIME:						
WINTER:	95	95	95	92	81	73
SPRING:	95	95	95	95	89	63
SUMMER:	92	95	95	95	68	34
FALL:	95	95	95	92	89	84
SNR > 20						
NIGHTTIME:						
WINTER:	2	44	65	55	0	0
SPRING:	10	31	42	18	2	0
SUMMER:	10	31	42	18	0	0
FALL:	2	21	29	18	0	0
DAYTIME:						
WINTER:	95	95	95	84	26	10
SPRING:	73	95	95	95	55	34
SUMMER:	60	95	92	81	31	10
FALL:	92	95	95	84	47	23

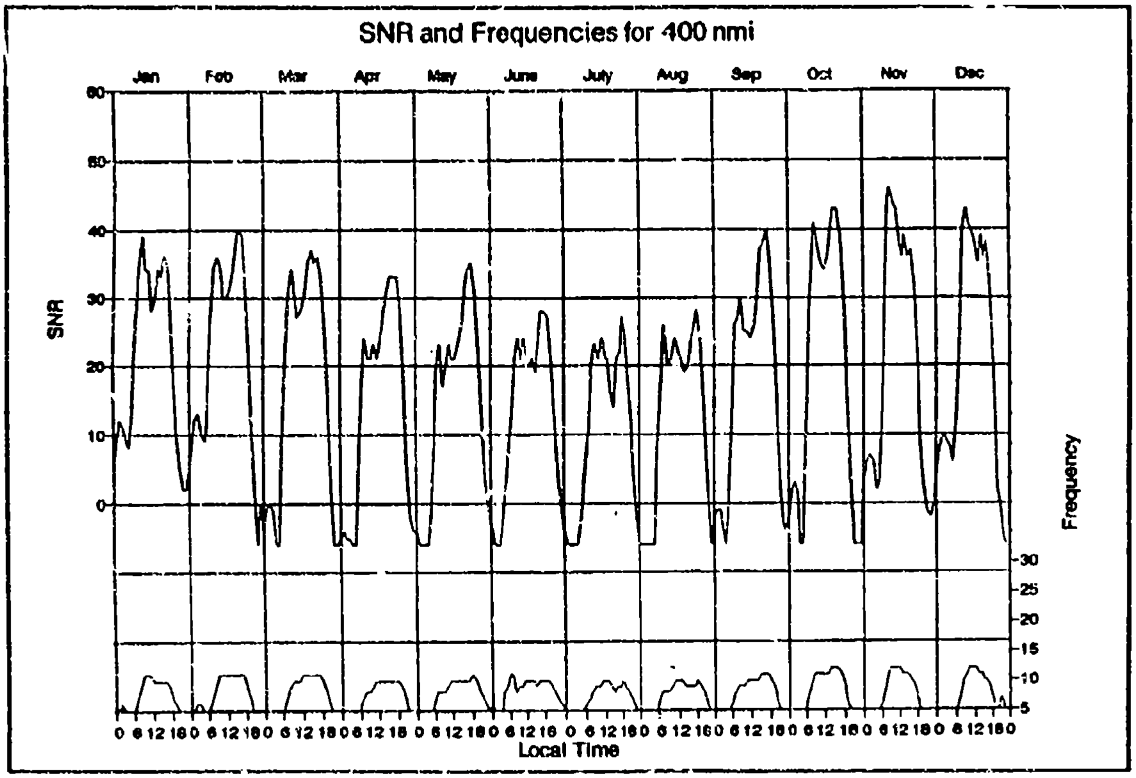

Figure 13. Forecast SNR and Optimum Frequencies for Cessna 400 nmi from the Radar at Northwest, Va. (SSN=10)

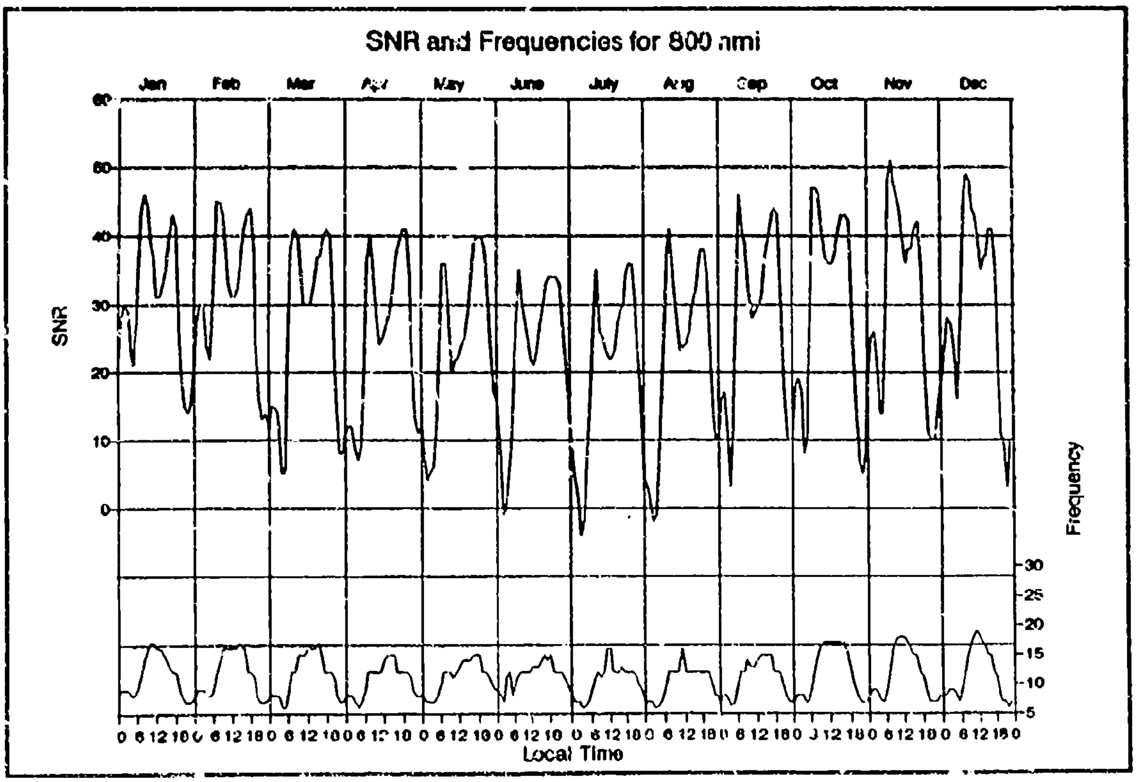

Figure 14. Forecast SNR and Optimum Frequencies for Cessna 800 nmi from the Radar at Northwest, Va. (SSN=10)

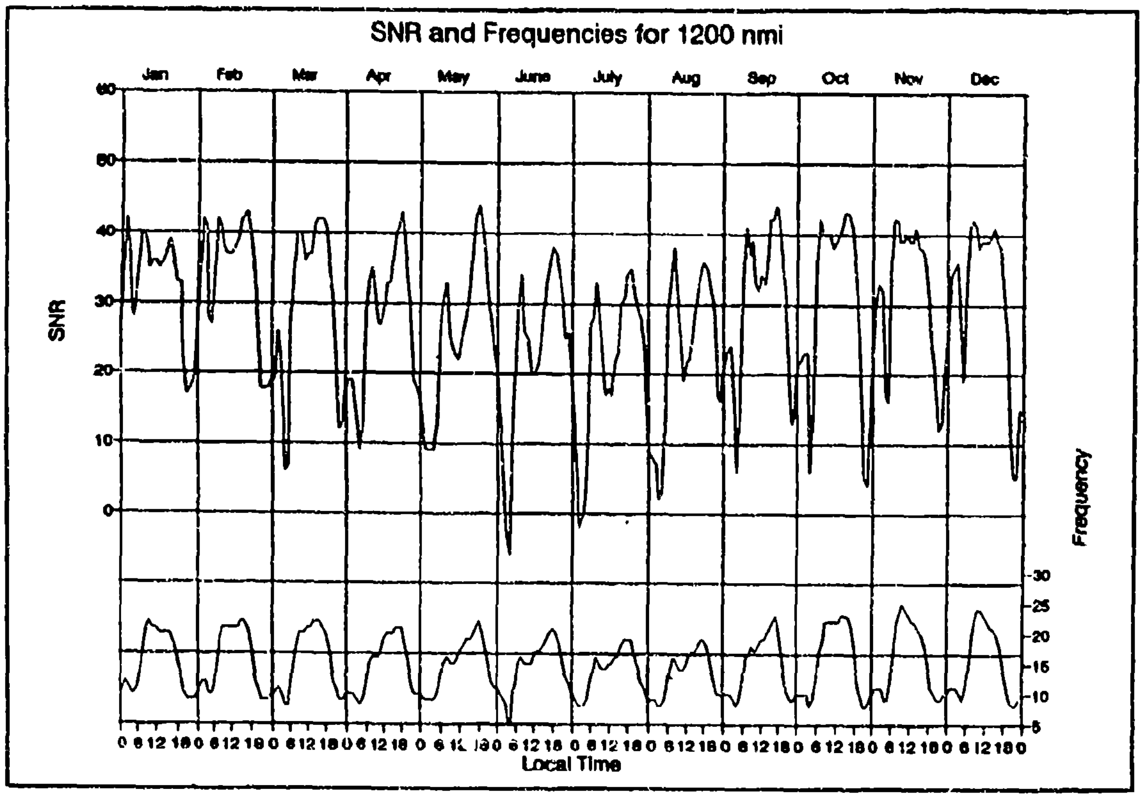

Figure 15. Forecast SNR and Optimum Frequencies for Cessna 1200 nmi from the Radar at Northwest, Va. (SSN=10)

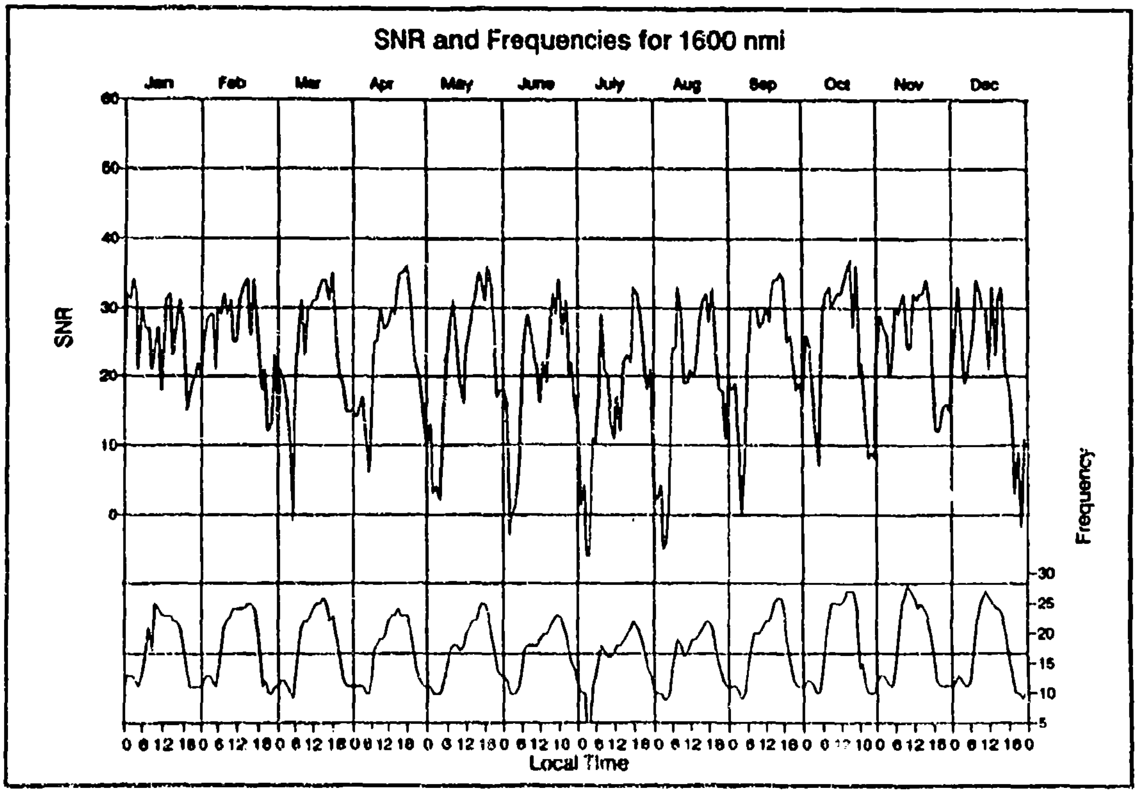

Figure 16. Forecast SNR and Optimum Frequencies for Cessna 1600 nmi from the Radar at Northwest, Va. (SSN=10)

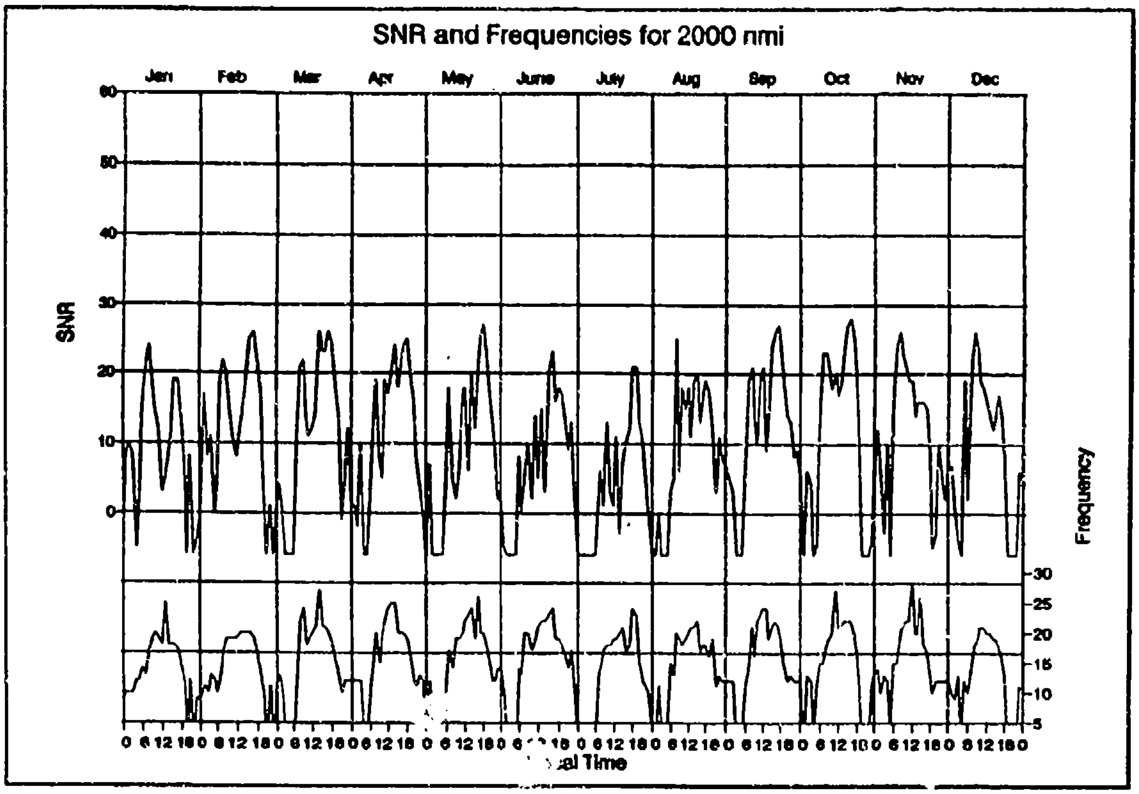

Figure 17. Forecast SNR and Optimum Frequencies for Cessna 2000 nmi from the Radar at Northwest, Va. (SSN=10)

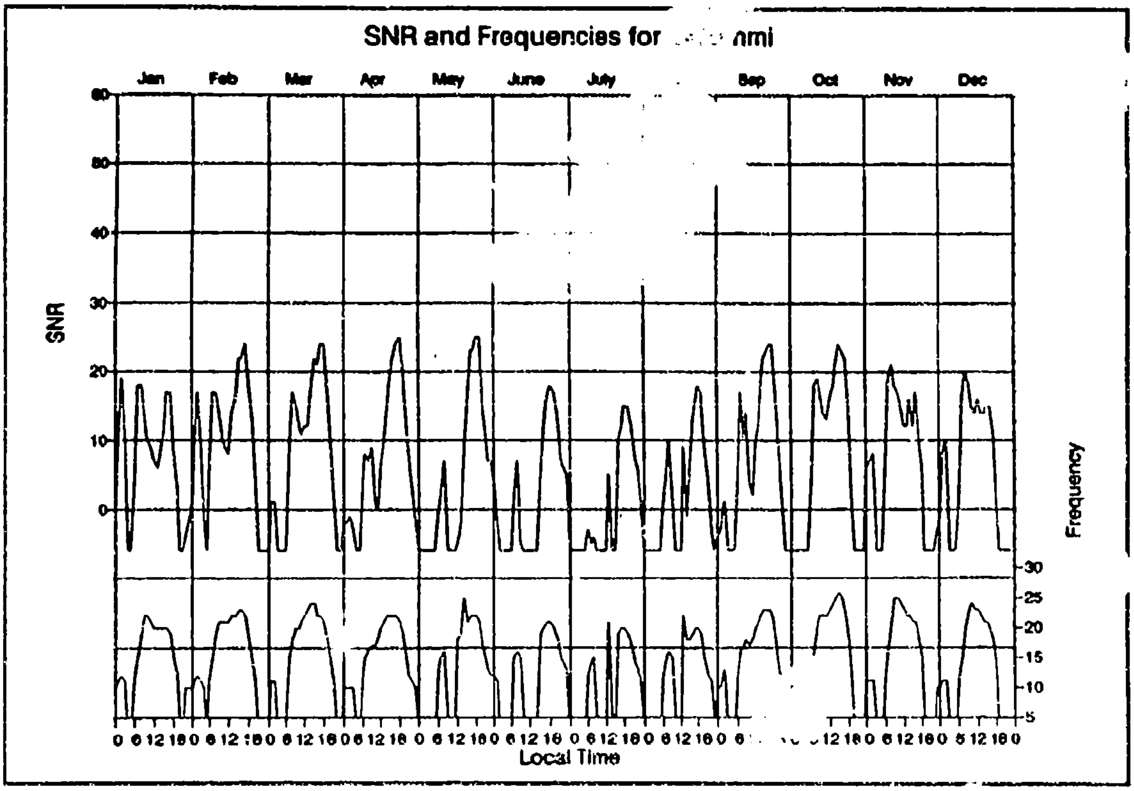

Figure 18. Forecast SNR and Optimum Frequencies for Cessna 2400 nmi from the Radar at Northwest, Va. (SSN=10)

Table 2. RADARC Availability(%) predictions for Cessna 206 Detection at Northwest, Va. (SSN=10)

Target Range =	400	800	1200	1600	2000	2400 nmi
SNR > 0						
NIGHTTIME:						
WINTER:	81	95	95	92	52	39
SPRING:	34	95	95	92	55	39
SUMMER:	42	76	81	79	44	39
FALL:	50	95	95	92	58	29
DAYTIME:						
WINTER:	95	95	95	95	95	95
SPRING:	95	95	95	95	95	79
SUMMER:	95	95	95	95	89	47
FALL:	95	95	95	95	95	95
SNR > 10						
NIGHTTIME:						
WINTER:	29	87	89	87	13	10
SPRING:	18	65	76	76	21	15
SUMMER:	21	50	60	55	21	13
FALL:	15	65	84	76	18	2
DAYTIME:						
WINTER:	95	95	95	95	81	68
SPRING:	95	95	95	95	76	52
SUMMER:	95	95	95	95	52	21
FALL:	95	95	95	95	87	79
SNR > 20						
NIGHTTIME:						
WINTER:	2	55	65	52	0	0
SPRING:	10	29	39	23	2	2
SUMMER:	10	34	42	26	2	0
FALL:	2	26	52	36	0	0
DAYTIME:						
WINTER:	95	95	95	89	23	7
SPRING:	81	92	95	89	36	26
SUMMER:	63	95	79	65	7	0
FALL:	95	95	95	89	44	23

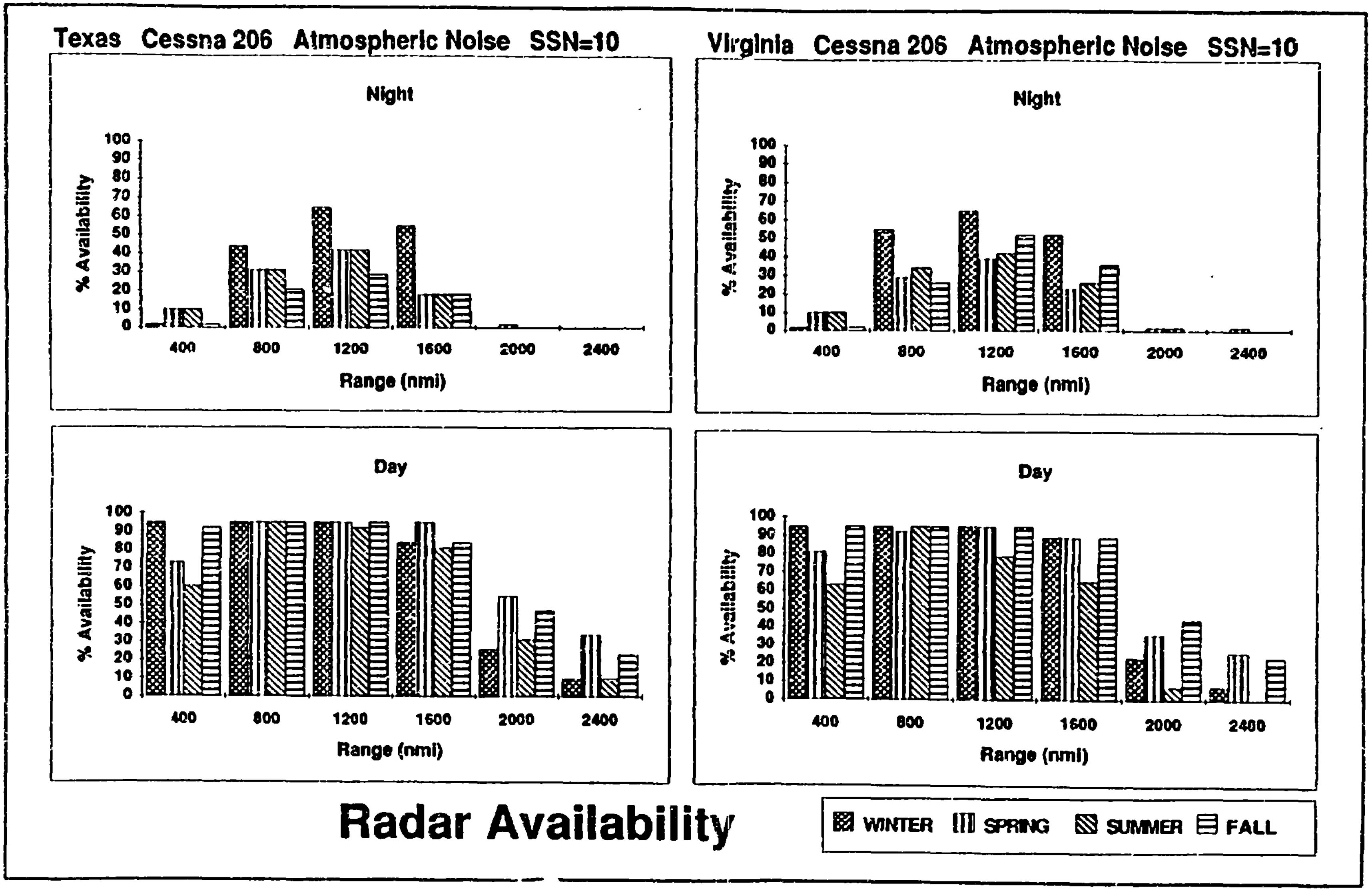

Figure 19. Radar Availability for Beeville, Tx. and Northwest, Va. with SNR threshold=20.

Appendix A. COMPUTER GENERATION OF FORECASTS

General Description

A forecast is done by computing the signal to noise ratio (SNR) with the radar equation using models of the radar, ionosphere, target, and noise. Using predicted median values of ionospheric parameters and noise for a selected month and hour, the computer program RADARC computes the ground range and SNR for each radar frequency, elevation angle, and propagation mode. The program outputs the results as a table of SNR values for ground range and frequency. An example of this "oblique ionogram sounding" output is shown in Figure A-1.

RADARC must be run 288 times (24 times for each hour in a day for each of the 12 months). The output files are combined to produce files with the 288 "oblique soundings". Two files are produced, one with ranges to 2000 nmi for print-out of the oblique soundings, and one with ranges to 4000 nmi for use in the forecast graphs and summary tables. From this second file, the VMS search command extracts the SNR versus frequency for each selected range and writes the output to a range result file, Rxxxx.PRN, where xxxx is the range in nmi. A portion of R0400.PRN, the range results file for 400 nmi, is shown in Figure A-2. A row for each month-hour shows the predicted SNR for each radar frequency, in one MHz steps from 5 to 28 MHz. The RADARC prediction computations are run on a VMS-VAX 3200 Model 38 workstation, taking about five hours in a batch job normally runs over-night. A VMS command procedure then extracts the range result files.

A file transfer program, such as the public domain program KERMIT, transfers the Rxxxx.PRN files to an IBM-compatible personal computer (PC) where utility programs reduce the range result files. The program PEAKS.EXE scans each row of the range result files for the peak SNR for that range, month, and hour. The SNR and the operating frequency giving that SNR are written into the file TABLE.DAT. Figure A-3 shows the first part of a TABLE.DAT file. This file contains all data used for plotting the forecast graph of diurnal variations for each month. The AVAIL.EXE program compute and print the summary table of percentage of night-time/day-time hours each season that are forecast to have SNR's exceeding given values. This program should be modified for different locations due to the change of time zone.

A spread-sheet program, such as Quattro-Pro, generates the forecast graphs after importing the TABLE.DAT file into a template FORECAST.WQ1. The template makes it easy to plot the graphs, but the user must first add a column for the local time (converted from GMT by subtracting 5 hours for Virginia and 6 hours for Texas) and sort the rows so that within each month the hours run from 0 to 23 hours local time.

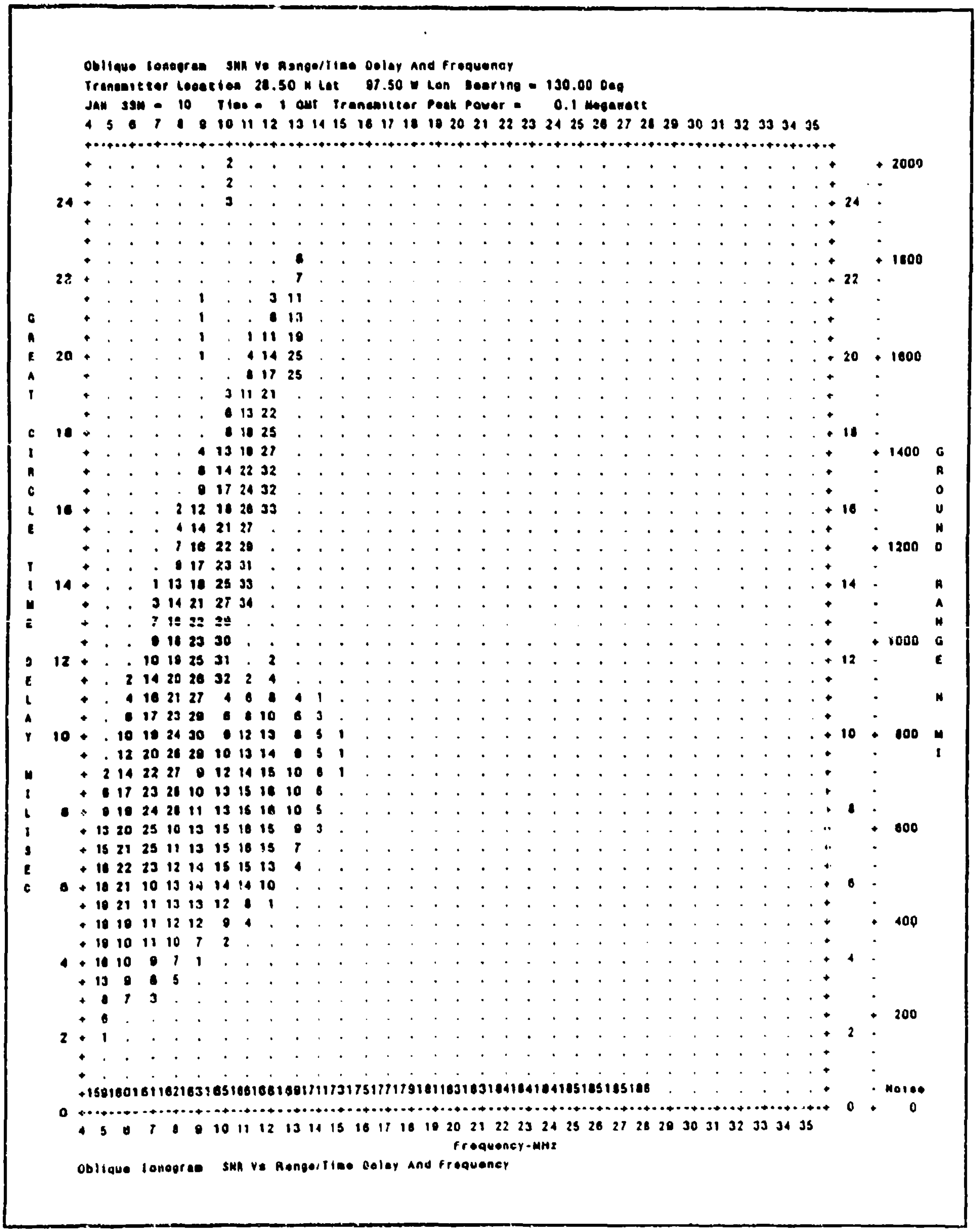

Figure A-1. An example of a RADARC Oblique Ionogram Sounding.

	GMT	5					10					15					20					25					30					35	Range
Jan	1	19	19	11	12	12	9	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	2	16	8	9	10	8	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	3	13	6	7	7	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	4	11	4	5	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	5	11	3	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	6	13	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	7	16	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	8	17	21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	9	17	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	10	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	11	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	12	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	13	10	24	28	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	14	7	17	28	36	40	42	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	15	.	9	19	28	37	41	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	16	.	.	12	23	31	38	41	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	17	.	.	12	26	34	39	42	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	18	.	.	6	20	28	34	35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	19	.	.	8	22	30	35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	20	.	4	17	28	35	39	41	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	21	8	20	28	37	41	44	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
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	6	12	4	4	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	7	15	18	6	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	8	17	21	22	5	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	9	16	20	6	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	10	13	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	11	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	12	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	13	12	23	28	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	14	4	15	29	35	39	39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	15	.	7	17	29	36	40	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	16	.	.	16	29	36	41	45	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	17	.	.	10	23	31	37	40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	18	.	.	9	21	29	35	38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	19	.	.	8	20	28	34	38	38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	20	.	.	16	28	36	41	44	45	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	21	2	15	23	33	39	43	46	47	42	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
	22	16	25	33	40	44	47	49	50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400

Frequency (MHz)

Figure A-2. A portion of the file R0400.PRN, a table of SNR for range 400 nmi, which is extracted from a sequence of 288 Oblique Ionogram Soundings, one of each hour of the day and each of the twelve months.

Range =		400		800		1200		1600		2000		2400 nmi	
month	GMT	SNR	freq	SNR	freq	SNR	freq	SNR	freq	SNR	freq	SNR	freq
1	1	19	5	30	9	29	11	25	13	2	10	0	0
1	2	16	5	24	8	24	10	21	12	14	13	0	0
1	3	13	5	24	8	26	10	27	12	16	13	0	0
1	4	11	5	24	8	25	10	28	12	12	13	0	0
1	5	11	5	24	8	27	10	30	12	0	0	0	0
1	6	13	5	26	8	37	11	34	12	10	10	10	11
1	7	17	6	34	9	37	11	37	13	12	10	11	11
1	8	21	6	40	10	47	12	36	14	18	15	14	11
1	9	19	6	36	9	48	12	33	13	4	9	5	10
1	10	15	5	28	8	31	10	33	12	0	0	0	0
1	11	10	5	20	7	21	9	24	11	0	0	0	0
1	12	13	5	30	9	35	11	31	13	0	0	11	12
1	13	28	7	49	12	46	15	33	17	25	14	22	16
1	14	42	10	53	15	46	19	39	21	28	18	22	20
1	15	44	11	51	17	43	22	27	17	25	20	19	22
1	16	41	11	47	17	41	22	21	25	20	20	16	22
1	17	42	11	44	17	42	21	25	24	19	19	15	21
1	18	35	11	38	16	43	21	35	24	16	26	11	20
1	19	35	10	37	16	44	21	36	24	12	18	18	21
1	20	41	11	40	16	44	21	29	24	18	19	19	21
1	21	44	10	44	16	46	22	33	25	25	20	24	22
1	22	44	10	46	15	47	21	28	23	27	19	26	21
1	23	39	9	46	12	40	17	34	20	21	16	14	17
1	24	29	7	41	11	35	14	17	15	13	12	5	13
2	1	27	6	40	10	39	13	20	14	23	15	12	12
2	2	19	5	27	8	27	10	23	12	18	13	0	0
2	3	12	5	24	8	28	10	24	11	19	12	1	10
2	4	9	5	18	7	19	9	21	11	10	12	1	10
2	5	9	5	23	8	28	10	20	11	0	0	1	10
2	6	12	5	26	8	36	11	27	12	9	10	10	11
2	7	18	6	34	9	44	12	38	14	19	11	19	12
2	8	22	7	43	10	48	13	38	15	21	11	21	12
2	9	20	6	41	10	46	12	34	14	9	15	2	10
2	10	13	5	27	8	31	10	34	12	0	0	0	0
2	11	4	5	15	7	19	9	10	10	0	0	0	0
2	12	15	5	27	8	36	11	27	12	6	10	4	11
2	13	28	7	50	12	46	15	34	17	24	14	21	16
2	14	39	9	51	14	47	19	29	15	28	17	24	20
2	15	44	11	51	17	43	21	38	24	24	19	22	22

Figure A-3. Example of data file of SNR and Frequency predictions for different ranges from a table of SNR for each range.

User Instructions

To simplify computer generation of a performance forecast, most of the required user commands can be done by VMS command procedures on the VAX workstation and by DOS batch files on the PC.

The instructions for the VMS workstation are done by the following command procedures in Directory USERDISK:[HUDNALL.RADARC.FORECAST]

FORECAST.COM - does all VMS steps required
JOB.COM - control card images for the RADARC runs, JOB.COM must be edited by the user for the site latitude, logitude, and bearing
PART1.COM - submits the edited job control file to the batch queue for the 288 runs of RADARC
PART2.COM - uses the following command procedures to create the range result files
COMBINE.COM, MAKEALL.COM, MAKE2K.COM, MAKE4K.COM, RANGES.COM

USERDISK:[HUDNALL.RADARC.FORECAST]FORECAST.COM

```
$!!!!!!!!!!!!!!!!!!!! FORECAST.COM !!!!!!!!!!!!!!!!!!!!!!
$!
$!      These are the VMS steps to do a Performance Forecast
$!
$!
$ set verify
$!                       ! assign logical name to directory with forecast routines
$!
$ assign USERDISK:[hudnall.radarc.forecast] FORECAST
$!
$                        ! assign LOCATION to directory
$!                       !    for job file and output files
$!
$ assign userdisk:[hudnall.radarc.forecast.beeville] LOCATION
$!
$!                       ! create the directory for the job file
$!                       ! and resultant data files
$ create/dir LOCATION
$!                       ! job file will control the 288 runs of RADARC,
$!                       ! with a run for each of 24 hours in day, 12 months
$!
$ copy FORECAST:job.com LOCATION:job.com
$!
$!                       ! use editor to modify job control file
$ vmacs LOCATION:job.com  ! (or edit LOCATION:job.com)
$
$ @FORECAST:part1.com    ! this command procedure will submit the
$!                       !    job control file to the BATCH queue,
$!                       !    the job will take about five hours.
$                        ! The job will create the FOR030.DAT
$!                       !    RADARC output files for each month and hour.
$!                       ! The files are named m01h01.f30, m01h02.f30, ... ,
$!                       !     m12h23.f30, and m12h24.f30.
$!                       !  Other data files written by RADARC are deleted at each
$!                       !     step of the job
```

```
$!  . . .              ! wait for the batch job to run .......
$!                                  ........ probably overnight
$!  . . .              ! ......... continue the next day with remaining steps
$!
$ @FORECAST:part2.com
```

USERDISK:[HUDNALL.RADARC.FORECAST]PART1.COM;1

```
$ submit/QUEUE=ZERO/notify/noprint LOCATION:job.com
```

USERDISK:[HUDNALL.RADARC.FORECAST]PART2.COM;1

```
$ @COMBINE.COM   ! combines the hourly files for each month
$!               !     into a monthly file and then deletes the hourly files
$ @MAKEALL.COM   ! Makes the file ALL.F30 by concatinating the 12 monthly files
$ @MAKE2K.COM    ! Makes the file of ionograms for 2k max range
$ @MAKE4K.COM    ! Makes the file of ionograms for 4k max range
$ @RANGES.COM    ! Creates range files that are used by PC routines
```

USERDISK:[HUDNALL.RADARC.FORECAST]COMBINE.COM;2

```
$! COMBINE.COM - combines the hourly files for each month into a monthly file
$!               and then deletes the  hourly files
$ set verify
$ copy m01h*.f30 m01.f30
$ delete m01h*.f30;*
$ copy m02h*.f30 m02.f30
$ delete m02h*.f30;*
$ copy m03h*.f30 m03.f30
$ delete m03h*.f30;*
$ copy m04h*.f30 m04.f30
$ delete m04h*.f30;*
$ copy m05h*.f30 m05.f30
$ delete m05h*.f30;*
$ copy m06h*.f30 m06.f30
$ delete m06h*.f30;*
$ copy m07h*.f30 m07.f30
$ delete m07h*.f30;*
$ copy m08h*.f30 m08.f30
$ delete m08h*.f30;*
$ copy m09h*.f30 m09.f30
$ delete m09h*.f30;*
$ copy m10h*.f30 m10.f30
$ delete m10h*.f30;*
$ copy m11h*.f30 m11.f30
$ delete m11h*.f30;*
$ copy m12h*.f30 m12.f30
$ delete m12h*.f30;*
```

USERDISK:[HUDNALL.RADARC.FORECAST]MAKE2K.COM;1

```
$! MAKE2K.COM - Makes the file of ionograms for 2k max range

$ search all.f30 "+ 1800"/win=(10,48)/output=ALL2K.prn
```

USERDISK:[HUDNALL.RADARC.FORECAST]MAKE4K.COM;1

```
$! MAKE4K.COM - Makes the file of ionograms for 4k max range
```

```
$ search all.f30 "+ 3600"/win=(10,47)/output=ALL4K.prn
```

USERDISK:[HUDNALL.RADARC.FORECAST]MAKEALL.COM;2

```
$! MAKEALL.COM - Makes the file ALL.F30 by concatinating the 12 monthly files

$ set verify
$ copy m01.f30,m02,m03,m04,m05,m06,m07,m08,m09,m10,m11,m12 all.f30
$ set noverify
```

USERDISK:[HUDNALL.RADARC.FORECAST]RANGES.COM;4

```
$! RANGES.COM  -  makes range files that are used by PC routines
$
$ set verify
$ search LOCATION:all4k.prn "+  400"/output=LOCATION:r0400.prn
$ search LOCATION:all4k.prn "+  800"/output=LOCATION:r0800.prn
$ search LOCATION:all4k.prn "+ 1200"/output=LOCATION:r1200.prn
$ search LOCATION:all4k.prn "+ 1600"/output=LOCATION:r1600.prn
$ search LOCATION:all4k.prn "+ 2000"/output=LOCATION:r2000.prn
$ search LOCATION:all4k.prn "+ 2400"/output=LOCATION:r2400.prn
$ set noverify
```

USERDISK:[HUDNALL.RADARC.FORECAST]JOB.COM;1

```
$ RUN USERDISK:[SKAGGS.RADARC.VAX.PREDICT.MODTEST.JRDBVL]MODWRITE30RADARCTEST.EXE
 2   111010101      1.0   1.0   1.0   0.7    204.         -1.0  60.0
                     m01010
36.8     76.3 120.0  0.126   0.0   06.0   02.5      1.0  1. 000 2  1.0   12
175.0-1.0                       1400.    2800.                            2
05.  28.  1.

$ copy for030.dat userdisk:[hudnall.radarc.beeville]m01h01.f30
$ del for*.dat;*
$ RUN USERDISK:[SKAGGS.RADARC.VAX.PREDICT.MODTEST.JRDBVL]MODWRITE30RADARCTEST.EXE
 2   111020201      1.0   1.0   1.0   0.7    204.         -1.0  60.0
                     m01010
36.8     76.3 120.0  0.126   0.0   06.0   02.5      1.0  1. 000 2  1.0   12
175.0-1.0                       1400.    2800.                            2
05.  28.  1.

$ copy for030.dat userdisk:[hudnall.radarc.beeville]m01h02.f30
$ delete for*.dat;*
$ RUN USERDISK:[SKAGGS.RADARC.VAX.PREDICT.MODTEST.JRDBVL]MODWRITE30RADARCTEST.EXE
 2   111030301      1.0   1.0   1.0   0.7    204.         -1.0  60.0
                     m01010
36.8     76.3 120.0  0.126   0.0   06.0   02.5      1.0  1. 000 2  1.0   12
175.0-1.0                       1400.    2800.                            2
05.  28.  1.

$ copy for030.dat userdisk:[hudnall.radarc.beeville]m01h03.f30
$ del for*.dat;*
$ RUN USERDISK:[SKAGGS.RADARC.VAX.PREDICT.MODTEST.JRDBVL]MODWRITE30RADARCTEST.EXE
 2   111040401      1.0   1.0   1.0   0.7    204.         -1.0  60.0
                     m01010
36.8     76.3 120.0  0.126   0.0   06.0   02.5      1.0  1. 000 2  1.0   12
175.0-1.0                       1400.    2800.                            2
05.  28.  1.
```

. . . and so forth for all 24 hours of each of 12 months . . .

After the range result files have been created on a VAX workstation, the files are transferred to a personal computer for formatting the results, plotting the forecast graphs, and reducing the data to the forecast tables.

Much of the work on the PC is done by the following DOS batch file:

```
peaks r0400.prn > r0400.dat
peaks r0800.prn > r0800.dat
peaks r1200.prn > r1200.dat
peaks r1600.prn > r1600.dat
peaks r2000.prn > r2000.dat
peaks r2400.prn > r2400.dat
cut -c1-5  r0400.dat >tmp.0
cut -c6-80 r0400.dat >tmp.1
cut -c6-80 r0800.dat >tmp.2
cut -c6-80 r1200.dat >tmp.3
cut -c6-80 r1600.dat >tmp.4
cut -c6-80 r2000.dat >tmp.5
cut -c6-80 r2400.dat >tmp.6
paste tmp.0 tmp.1 tmp.2 tmp.3 tmp.4 tmp.5 tmp.6> r.dat
copy \projects\forecast\heading.txt+r.dat table.dat
avail 1 > a01
avail 11 > a11
avail 21 > a21
avail 31 > a31
avail 41 > a41
copy a01+a11+a21+a31+a41 avail.prn
```

Use Quattro-Pro to import the file TABLE.DAT. Convert the time from GMT to local (subtract five hours for Virginia or six hours for Texas). Re-order the rows so that hours run from 0 to 23 local in each month. Annotate the graphs with site location, selected range, radar parameters, and sun spot number.

REFERENCES

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2. Thomason, J., G. Skaggs, and J. Lloyd. A Global Ionospheric Model, NRL report-8321. 20, August 1979.